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Quantification, distribution and major predictors of soil N content along a range of forest ecosystems and climatic conditions in Italy

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Introduction

N is known to be the most limiting element for vegetation growth in temperate and boreal forests furthermore, N cycling in forests is projected to be most affected by future global warming (Bai *et al*., 2013). In order to determine the C sequestration potential of soils, it is imperative that soil N stocks and C/N ratios are quantified (Luo *et al*., 2006; de Vries *et al*., 2009).

Objectives

The main aim of the present study was to investigate the explanatory factors of the N content and C/N ratio of Italian forest soils by means of BRT (Boosted Regression Tree) models in order to improve our knowledge regarding soil N predictors at a regional scale.

Materials & Methods

The data collected by the second Italian National Forest Inventory, on 1404 plots, spanning a wide range of temperature and precipitation values (10° latitudinal range; Fig. 1), represented a unique opportunity to calculate N content and C/N ratio of the different soil layers to a depth of 30 cm. BRT models were applied to investigate the main determinants of soil N distribution and C/N ratio. A total of 16 plot-related independent variables were sorted into three main groups: site, stand and soil variables and tested in eight BRT models. For the application of BRT models, we used the "dismo" (Species Distribution Modeling, v. 1.0-12; Hijmans *et al*., 2016) and "gbm" (Generalized Boosted Regression Trees, v. 2.1.1; Ridgeway, 2015) R packages.

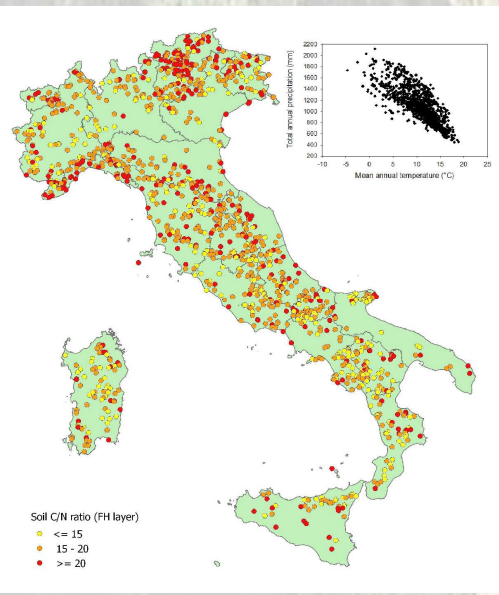

Fig. 1 Distribution of the sampling points grouped into three classes according to C/N ratio of the FH (fermentation-humus) soil layer. Upper corner panel: the distribution of the sampling points according to the relationship between mean annual temperature and total annual precipitation.

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Results

Forest category was shown to be the main explanatory factor of soil N variability in seven out of eight BRT models, both for forest floor and mineral soil layers (Table 1). Latitude explained a larger share of variability than single climate variables. BRT models explained, on average, the 49 % of the data variability, with the remaining fraction likely due to soil-related variables that were unaccounted for. The lowest FH layer C/N value (15.1) belonged to other broadleaf forests (BD) whereas Mediterranean pine (Pim) forests had the highest (C/N=21.8; Fig. 2). The Pim forests C/N value was significantly different from all the broadleaf C/N values, apart from the evergreen broadleaf forests (EvB), whereas considering the conifer forests alone, the only statistically significant difference was with silver fir (Fi; Fig. 2). No statistically significant differences in C/N ratio were detected among broadleaf forest categories.

Table 1 – BRT model results for soil N (g m^{-2}) and C/N ratio. The three main model explanatory factors are listed in descending order of relative importance (RI %, in brackets).

Dependent Variable	1st Expl. factor	2nd Expl. factor	3rd Expl. factor	N
N, L (g m^{-2})	For Cat (26.3)	FH depth (16.1)	T (14.2)	1404
N, FH (g m^{-2})	S rocks (21.6)	For Cat (19.0)	FH depth (14.5)	1404
N, Mineral $_{0\text{-}10\ cm}$ (g m^{-2})	For Cat (27.8)	S rocks (10.1)	Soil (9.5)	1404
N, Mineral $_{10\text{-}30\ cm}$ (g m^{-2})	For Cat (23.7)	Soil (13.2)	S rocks (12.0)	1404
N, total (g m^{-2})	For Cat (24.8)	Lat (12.0)	Soil (11.7)	1404
C/N, L	For Cat (49.1)	Lat (7.7)	Dom H (7.5)	1275
C/N, FH	For Cat (32.2)	Slope (14.6)	Lat (9.3)	1288
C/N, total	For Cat (38.8)	Soil (11.1)	Lat (8.7)	1404

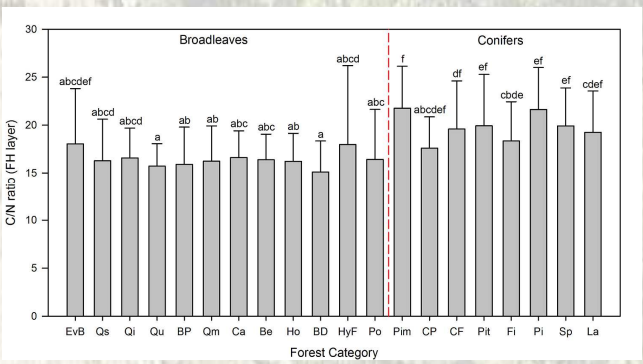

Fig. 2 Average C/N ratio of the FH layer according to forest category. Vertical bars represent the standard deviation. Different letters over the bars indicate statistically significant differences in median C/N ratio (Kruskal-Wallis ANOVA by Ranks and Multiple comparison p-values tests). Forest categories were ordered within each group by increasing average latitude.

Conclusions

Forest category was the main explanatory factor of soil N, both for the organic (litter and FH) and mineral soil layers to a depth of 30 cm explaining on average about 30% of the variability in N and C/N ratios. Other important variables were soil type and latitude. The latter represents a proxy for different ecological factors acting together to influence soil N pools and was better suited to explain N variability than single climatic variables per se. On average the BRT models explained approximately 50% of the N variability, the remaining part is likely attributable to soil-related variables not considered in the models such as: soil acidity, soil texture and rock type (data not available).

Acknowledegements

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